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First record of stygobiotic gastropod genus *Travunijana* Grego & Glöer, 2019 (Mollusca, Hydrobiidae) from Montenegro

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Abstract

The stygobiotic genus *Travunijana* Grego & Glöer, 2019 is one of the typical elements of the subterranean freshwater fauna of the Trebišnjica River Basin in Bosnia and Hercegovina. The previous records of the genus suggested that its distribution was limited to the basin of the Trebišnjica River and adjacent parts of the southwestern Neretva Basin. In this paper we describe a new species, *Travunijana djokovici* **sp. nov.** from "Vriješko Vrelo" spring in Montenegro. The recent finding of a new species in the Skadar Lake basin (The Drin River system) suggests the possibility of a subterranean route between the Trebišnjica and the Drin drainages, indicating that likely the endemic subterranean fauna in both basins has a lower level of historical isolation than has been considered so far.

Keywords

Bosnia, cave, karst-water, *Plagigeyeria*, spring

Introduction

The genus *Travunijana* Grego & Glöer, 2019 was only recently recognised based on its characteristic anatomy and shell morphology (Grego and Glöer 2019). Recent revision of another stygobiotic genus *Plagigeyeria* Tomlin, 1930 by Grego (2020) revealed that a number of species of the latter genus belongs to the genus *Travunijana*, and that the

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shell morphology with its protoconch sculpture is suitable evidence for the separation of these two genera (Grego 2020). The current distribution of ten taxa, i.e. *Travunijana vruljakensis* (Grego & Glöer, 2019), *T. ovalis* (Kuščer, 1933), *T. robusta* (Schütt, 1959), *T. robusta asculpta* (Schütt, 1972), *T. klemmi* (Schütt, 1961), *T. nitida* (Schütt, 1963), *T. angelovi* (Schütt, 1972), *T. edlaueri* (Schütt, 1961), *T. tribunicae* (Schütt, 1963) and *T. gloeri* (Grego, 2020) indicates that the Trebišnjica River Basin is the centre of endemism of the genus *Travunijana*. Outside the Trebišnjica River Basin, there are two records (a spring between Fatničko and Dabarsko Poljes and the spring of the Bunica near Mostar) from the southwestern part of the Neretva River Basin at its boundary with the Trebišnjica River Basin, with an intermittent divergence of the karst-water (Grego 2020) (Fig. 1).

The distribution pattern of the genus *Travunijana* appears to reflect well the relative isolation within the hydrogeological conditions with possible faunal dispersal pathways to adjacent basins. The genus is a typical element of the stygobiotic and crenobiotic fauna of the Trebišnjica River Basin, as a part of a remarkable and unique diversity that characterises the central part of the Dinaric Karst. The latter region is home to a number of typical stygobiotic species such as the olm *Proteus anguinus* (Laurenti, 1768), the bivalve *Mytilopsis kusceri* (Bole, 1962) and a polychaete, *Marifugia cavatica* (Absolon & Hrabě, 1930), whose southernmost distribution range is bounded by the Trebišnjica River Basin (see Pešić et al. 2018 for further discussion).

Recently, Pešić et al. (2020) moved the western border of the Southeastern Adriatic Ecoregion (which includes the Drin river system) west of the river Sutorina, located near the administrative border of Montenegro. In this concept, contrary to FEOW global freshwater ecoregion system, which places the eastern border of the Dalmatian Ecoregion near the town of Budva, the boundaries of the latter ecoregion ends or overlaps with the eastern boundary of the Trebišnjica River Basin (Lake Bileća) (Pešić et al. 2020).

The subterranean drainage boundaries between the Trebišnjica River Basin and Drin Basin together with the Kotor Bay drainage area is hydrogeologically well defined (Stevanović et al. 2014, Pešić et al. 2020) and might act as a barrier for stygobiotic and crenobiotic Mollusca dispersal. The existence of a subterranean barrier is supported by the finding of a number of typical mollusc genera at the both sides of the drainage boundaries. For the Trebišnjica Basin and the northward areas, the following stygobiotic and crenobiotic genera are typical, *viz. Mytilopsis* Conrad, 1958; *Travunijana* Grego & Glöer, 2019; *Emmericia* Brusina, 1870; *Belgrandia* Bourguignat, 1869; *Hadziella* Kuščer, 1932; *Kerkia* Radoman, 1978; *Narentiana* Radoman, 1973; *Belgrandiella* A. J. Wagner, 1928; *Dalmatinella* Radoman, 1973; *Sadleriana* Clessin, 1890; *Tanousia* Servain, 1881 and an undescribed genus represented by "*Pseudamnicola" troglobia* Bole 1961 (Kuščer 1933, Schütt 2000; Bilandžija et al. 2013; Beran et al. 2014, 2016; Rysiewska et al. 2017; Hirschfelder 2018, Falniowski et al. 2021). The above listed genera cannot be found in the Skadar Lake Basin (the Drin River system) and its associated Kotor Bay drainage basin, which have their typical freshwater malacofauna consisting of gastropod genera such as: *Bracenica* Radoman, 1973; *Anagastina* Radoman 1978; *Stygobium* Grego & Glöer, 2019; *Karucia* Glöer & Pešić, 2013; and

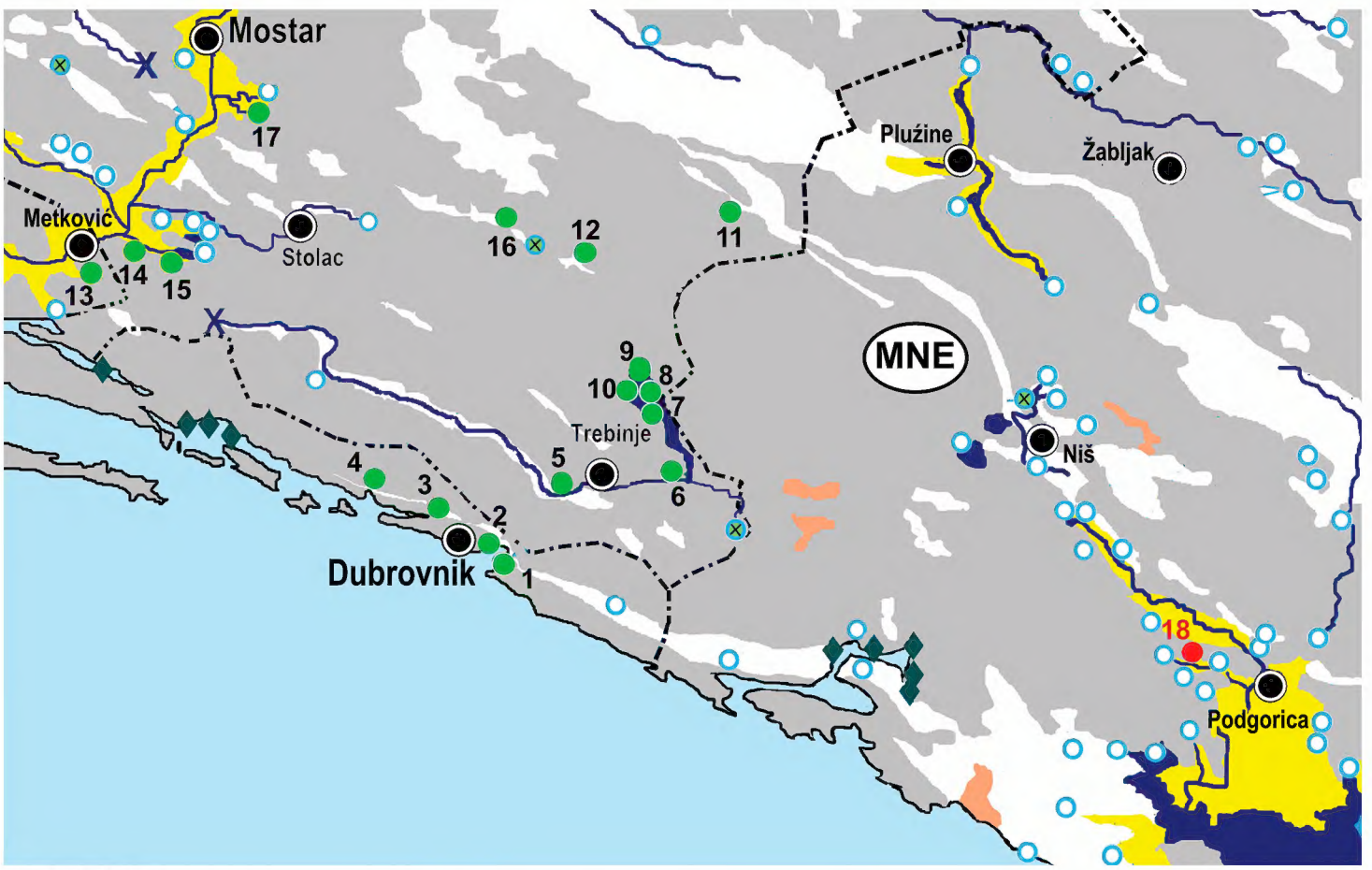

Figure 1. Distribution of the Genus *Travunijana* Grego & Glöer, 2019 (Green dots 1–17) and type locality of *Travunijana djokovici* sp. nov. (Red dot 18). Grey: Permeable karstified carbonates; White: impermeable unkarstified bedrocks; Yellow: Permeable alluvial deposits; Orange: sand deposits with limited permeability for subterranean gastropod dispersal. Light blue ring: karst springs; Blue ring with green centre and black X: estavelles; Dark green diamond: submarine or brackish karst spring.

Zeteana Glöer & Pešić, 2014 (Reischütz and Reischütz 2008; Pešić and Glöer 2012, 2013a, b; Reischütz et al. 2013, 2014, 2016; Glöer and Pešić 2014a, b; Glöer et al. 2015; Grego et al. 2017, 2019).

Several freshwater genera can be found on both sides of the drainage boundaries, but are represented in them by different species (Schütt 1961, 1963, 1972, 2000; Glöer and Grego 2015). Such stygobiotic genera include *Plagigeyeria* Tomlin, 1930; *Paladilhiopsis* Pavlović, 1913; *Iglica* A. J. Wagner, 1910; *Islamia* Radoman, 1973 and *Theodoxus* Roth, 1855 (for its subterranean species *T. subterrelictus* Schütt, 1963 in the Trebišnjica Basin) and *Adriohydrobia* Radoman, 1977 for crenobiotic fauna. Only one stygobiont hydrobiid genus and species, *Montenegrospeum bogici* Pešić & Glöer, 2013 is known to occur in both sides of the boundary over longer distances northward, suggesting that this euryvalent stygobiont is adapted to a broad range of subterranean habitats supporting its large dispersal (Falniowski et al. in press). In a similar way, the

more widespread crenobiont species such as *Radomaniola curta* (Küster, 1853) and *Litabithella chilodia* (Westerlund, 1886) can be found at both sides of the underground watershed boundaries (Radoman 1983).

Nevertheless, there is evidence for the existence of an underground hydrological connection between the Trebišnjica Basin and the neighbouring Skadar Lake Basin. A remarkable example is the existence of an intermittent karst-water connection which seasonally drains the water from the Skadar Lake Basin through the Gornjepoljski Vir Estavelle (628 m alt.) towards the "Nikšićko Vrelo" spring (468 m alt.) near Bileća in the Trebišnjica Basin. This unique subterranean route represents a distance of 38 km of aerial distance and 189 m elevational difference. The latter route is an aquatic migratory corridor for some of the stygobiotic species such as *Plagigeyeria zetatridyma* Schütt, 1960 (confirmed by empty shells; see Schütt 1970) and *Montenegrospeum bogici* (confirmed by molecular data, Falniowski et al. in press). The latter species were found at both sides of the drainage boundaries, indicating that the above-mentioned underground route plays an important role in their dispersal . There is an indication that a similar route is used by the crenobiont genus *Anagastina*, which was found at a single site in Trebinje (Grego, unpublished data). The current discovery of a new representative of genus *Travunijana* in "Vriješko Vrelo" spring belonging the Skadar Lake Basin, suggests a more complex pattern of spatial distribution of stygobiont habitats of the studied area than was hitherto known, indicating the possible existence of an underground path for the spread of subterranean species from the Trebišnjica Basin to the Drin Basin.

Material and methods

The studied material was collected during a field trip in April 2019 to both Montenegro and Bosnia and Hercegovina. The samples were collected by wet sieving (Grego et al. 2017) and sorted out from the sandy sediments, and fixed in 70–80% ethanol. The live specimens were transferred to 80% analytical ethanol. Photographs were made by a digital camera system Leica R8 (Leitz Photar 21 mm objective with Novoflex bellows), ImageJ scientific image analyzing software was used for making the measurements together with direct measurement with an eye-piece micrometer.

Abbreviations

HNHM	Hungarian Natural History Museum, Budapest;
NHMW	Naturhistorisches Museum, Wien;
SBMNH	Santa Barbara Museum of Natural History, California, USA;
JG	Collection Jozef Grego;
H	Shell height;
W	Shell width;
WB	Width of the body whorl;
HA	Aperture height;
WA	Aperture width.

Systematics

Superfamily Truncatelloidea J.E. Gray, 1840
Family Hydrobiidae Stimpson, 1865
Genus *Travunijana* Grego & Glöer, 2019

***Travunijana djokovici* sp. nov.**
http://zoobank.org/93FAB9F2-2C62-46B8-92D0-8494695354E5
Figs 3A, B, 4A, B

Typelocality. Montenegro • Danilovgrad district, Bandići Village, Vriješko Vrelo spring under road to Modro Oko Lake, left tributary of Matica River, 42.481206°N, 19.145484°E (Fig. 1 and 2).

Typematerial. ***Holotype*:** Typelocality: J. Grego, G. Jakab. M. Olšavský, M. Kováčiková leg. 20.04.2019, NHMW1132628.

***Paratypes*:** same data: NHMW113629/ 2 dry specimens, HNHM105300/ 2 dry specimens and 37 dry specimens T 1293 in coll. Grego.

Measurements. ***Holotype*** H 3.23 mm; W 1.77 mm; WB 1.46 mm; HA 1.44; WA 1.14.
Paratype H 3.33 mm; W 1.86 mm; WB 1.46 mm; HA 1.49; WA 1.26.

Other material. Same locality data: 12 fragmented shells in coll. JG T 1294.

Figure 2. Photo of the type locality of *Travunijana djokovici* sp. nov. (photo M. Olšavský).

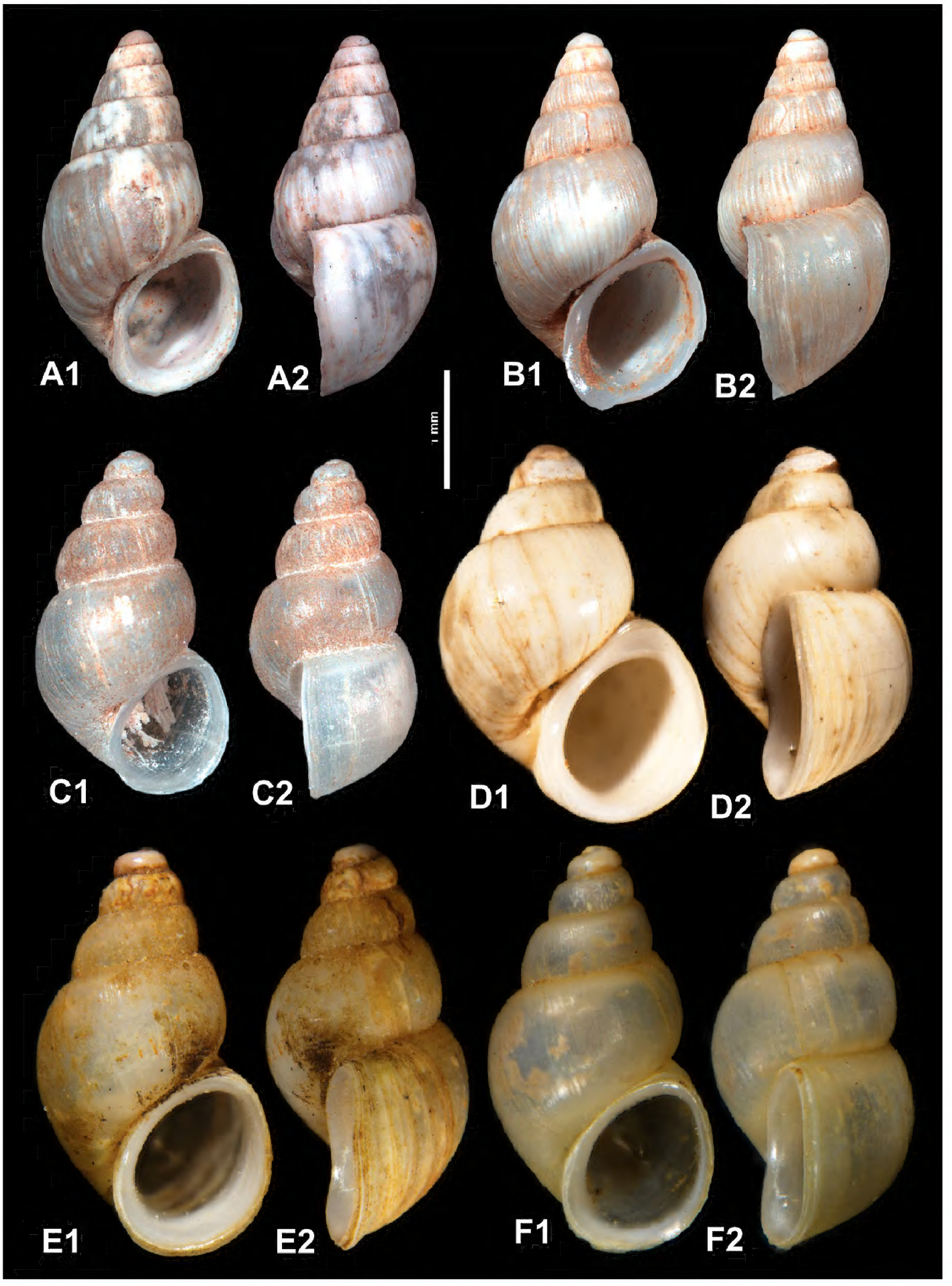

Figure 3. A, B *Travunijana djokovici* sp. nov. **A** holotype NHMW 1132628 **B** paratype, coll. JG F12393 (photo P. Glöer) **C** *T. vruljakensis* Grego & Glöer, 2019, holotype, HNHM Moll 100 174 **D** *T. ovalis* (Kuščer, 1933) **E, F** *T. gloeri* Grego, 2020 **E** holotype HNHM-Moll 104 418 **F** paratype JG F1340.

Differential diagnosis. The faintly pitted protoconch clearly distinguishes the new species from the members of the genus *Plagigeyeria* and indicates its position within the genus *Travunijana*. Moreover, the weakly sinuated columellar margin also supports its generic assignment.

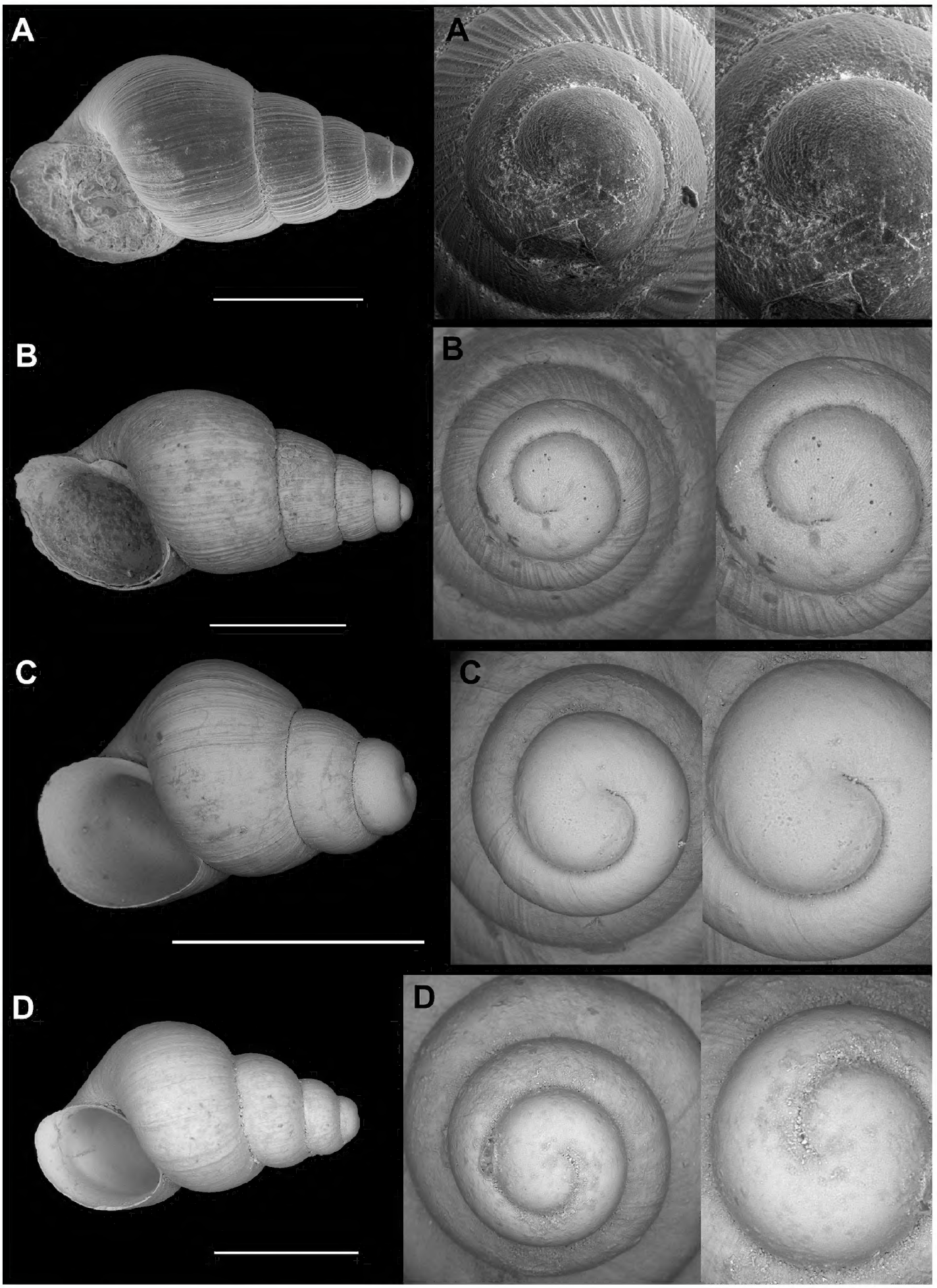

Figure 4. M protoconch SEM images of *Travunijana* **A, B** *Travunijana djokovici* sp. nov., paratype, SBMNH 632721) **C** *T. vruljakensis* Grego and Glöer, paratype SBMNH 625961 **D** *T. gloeri* Grego, 2020, paratype SBMNH 632722. Scale bars: 1 mm. (SEM SBMNH Vanessa Delnavaz).

Compared to the most closely related *Travunijana gloeri* Grego, 2020, *T. vruljakensis* Grego & Glöer, 2019 and *T. ovalis* (Kuščer, 1937), all from Trebišnjica Basin (Fig. 3C–F), the new species differs by its shell morphology, which has more elongate-

pyramidal shape, more distinct regular ribs on the shell surface and an elongate lens-like aperture, the latter with more distinct siphonal and anal grove.

Description. ***Shell:*** elongate-conical, milky whitish colour, periostracum yellowish, consisted of five moderately convex whorls with a semi-deep suture. The surface covered by dense, regular weak axial ribs. Aperture elongate, lens-like, its axis declined from the columella; the labral peristome straight in its lateral profile and slightly outward curved and callous. The columella peristome weakly sinuated at its middle part. The siphon and anal groves clearly indicated at the tips of elongated aperture. The umbilicus is tiny, almost closed and hidden behind the reflected columellar margin.

Protoconch very faintly and densely pitted, at the penultimate whorls smoothly transferring through weak malleated structures, faint regular growth lines into a regular weak ribbing covering the rest of the teleoconch.

Etymology. The new species is named after Novak Djokovic a famous Serbian tennisplayer to acknowledge his inspiring enthusiasm and energy.

Distribution. Montenegro; only known from the type locality.

Ecology. The type locality is a medium sized karst spring with stable water outflow, situated at the border of a limestone massif and alluvium of the Matica River. The status of empty shells washed out of the spring-head suggests its stygobiont habitat inside the karst conduit. The new species was syntopic with *Plagigeyeria* cf. *montenegrina* Bole, 1961, *Bracenica* cf. *spiridoni* Radoman, 1973, *Zeteana* sp. and *Montenegrospeum* cf. *bogici* (Pešić & Glöer, 2012) at its type locality thanatocoenosis.

Conservation status. Number of known locations (1) fewer than 5 and AOO (area of occupancy) smaller than 20 km^2. There is no reason to suppose that AOO, EOO (extent of occurrence), number of locations, number of subpopulations or the number or mature individuals are declining or extremely fluctuating. However, due to small AOO it is assessed as Vulnerable (VU) D2 species.

Discussion

The find-site of the stygobiotic *Travunijana djokovici* sp. nov. in the Skadar lake Basin belonging to the Southeastern Adriatic Ecoregion, is located 60 km southward from the main distribution range of the genus in Hercegovina and south Dalmatia. This represents not only a significant range extension of the genus (Grego 2020), but also indicates an enigmatic stygobiotic migration dispersal route through the relatively well defined subterranean drainage boundary between the Trebišnjica and Drin basins (Pešić et al. 2020). As mentioned in the Introduction section, the existence of such a boundary is supported by finding numerous stygobiotic and even crenobiotic Mollusca genera and species that are endemic to each of the neighbouring basins. Recently, Pešić et al. (2018, 2020) stated that the south-eastern border of the distribution area of some holodinaric species such as the cave salamander *Proteus anguinus*, the polychaete *Marifugia cavatica*, the hydrozoan *Velkovrhia* and the bivalvian *Mytilopsis kusceri*

coincided with the northwest administrative border of Montenegro, which indicates the existence of "the common biotic break of holodinaric taxa in the northwest region of Montenegro" (Pešić et al. 2020).

However it is known that the drainage boundaries do not represent absolute barriers for the dispersal of subterranean animals, and as we mentioned in the Introduction, there is at least one such karst conduit intermittently cross-connecting both basins and draining water from Gornjpoljski Vir Estavelle (the Drin River Basin) to "Nikšićko Vrelo" spring in the Trebišnjica Basin (Grego 2020). This intermittent connection is active at the high water saturation during both the winter and spring time. Its possible functionality as a migration path for stygobiotic Mollusca was firstly indicated by the finding of *Plagigeyeria zetatridyma*, a species typical for stygofauna of the Zeta basin of Drin River system, in "Nikšićko Vrelo" spring (Schütt 1972), one of the three major Trebišnjica wellspring outlets that have been submerged under Bilećko Lake since 1967. However, those finds were only empty shells transported through the 38 km long karst conduit and if ever a live specimen reached the Trebišnjica basin, the species was obviously never dispersed very far from the outlet springs near Bileća (Schütt 1972).

On the other hand, the recent finding of the live specimens of *Montenegrospeum bogici*, a species that was supposed to be limited to the Skadar Lake basin (the Drin River system), in springs located far downstream and upstream of Bileća (Falniowski et al. in press) suggests the possibility of stygobiont gastropod migration from the Drin river system to the Trebišnjica River Basin (Fig. 5). It is likely that a wide habitat preference of *M. bogici*, ranging from open cave streams and cave lakes to alluvial interstices, plays an important role in the large dispersal ability of the latter species (Falniowski et al. in press).

All the above mentioned observations indicate occurrence of only one dispersal mode from the Skadar Lake Basin to the Trebišnjica Basin through the above explained connection route. On the other hand, for *Travunijana*, we can speculate a similar dispersal mode though the same route but in an opposite direction, from Trebišnjica to Zeta River Basin, which probably occurred under different historical hydrological conditions. Despite the intensive sampling of the stygobiont malacofauna of the Skadar lake basin, which began in the middle of the last century (Pešić et al. 2018), no *Travunijana* specimen has been found in the studied region. Therefore, we assume that the underground route between the Trebišnjica and Zeta River Basins is the main way for *Travunijana* dispersal to the type locality near the Matica River.

The permanent submersion of the Trebišnjica spring group at Bileća by Lake Bilećko in the 1970s (when the Trebinje 1 Hydroelectric Power Plant was completed) has made it impossible to find living specimens of stygobiont species for molecular analysis and, consequently, no molecular evidence of the gene flow between two basins which would confirm the functionality of this migration route. Therefore, the origin and dispersal route of *T. djokovici* sp. nov. still remains a mystery. We cannot exclude the existence of similar divergent channels between the basins during the geological history of the area, especially knowing that the present hydrological situation does not necessarily have to reflect the paleohydrology. Last, but not least, anthropogenic changes in the directions

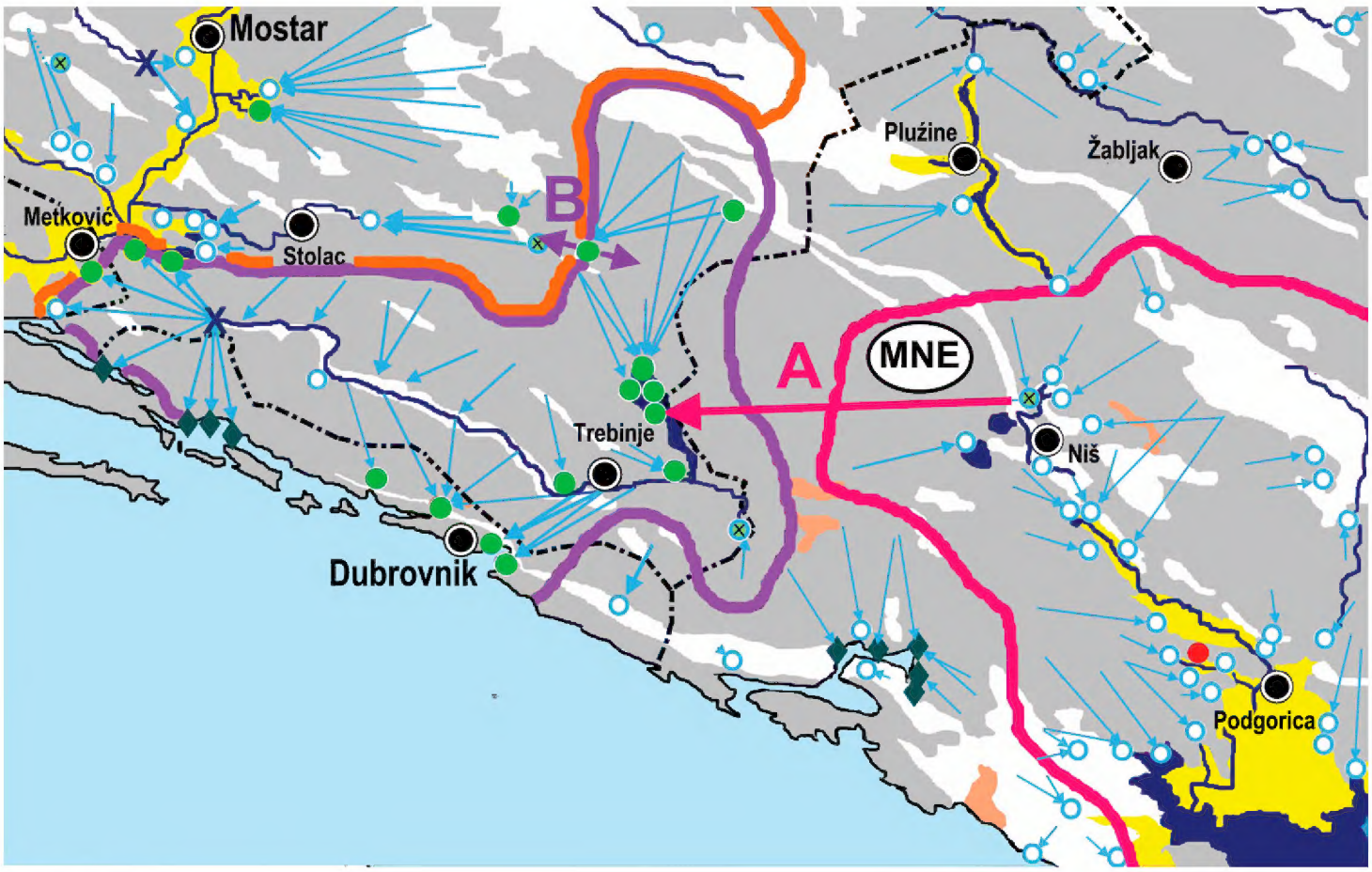

Figure 5. Distribution range of *Travunijana* and the type locality of *T. djokovici* sp. nov. superimposed by the local hydrogeological conditions.

of karst-water flows as a result of several large dams and diversion of river flows, with the aim of diverting water to power plants (on the rivers Zeta and Trebišnjica) make the understanding of possible migration routes of stygobionts even more difficult.

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